HIRDLS

SP-HIR-377B

HIGH RESOLUTION DYNAMICS LIMB SOUNDER

Originator:	John Whitney (with inputs from LM & UCB)	Date:	2004-04-19

Subject/Title: **HIRDLS On-Orbit Housekeeping & Status Data Monitoring**

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This document is intended to be read in conjunction with the associated Excel file Tools_List.xls

Keywords:

Oxford University
Atmospheric, Oceanic & Planetary Physics
Parks Road
OXFORD OX1 3PU
United Kingdom

University of Colorado, Boulder
Center for Limb Atmospheric Sounding
3300 Mitchell Lane
Boulder, CO 80301
USA

EOS

Background & Summary

Extensive consideration has been given to the processing and analysis of HIRDLS on-orbit housekeeping (HK) and status telemetry data by several members of the HIRDLS team. An attempt has been made here to put together an optimum and consistent plan to extract the maximum of relevant information with the minimum of duplication.

Over the past 3 years or more, various data handling and analysis tools have been written - mainly by Lockheed Martin (LM) - to support HIRDLS integration, testing and performance verification prior to launch. Most of these tools, together with those produced at Oxford and at UCB, have been thoroughly tested and exercised and many will form part of the tool set to be used after launch (**see section below on data file formats**)

The main considerations and objectives are:

(a) to maintain existing analysis baselines and to ensure continuity of data interpretation and presentation;

(b) to address the potential difficulties due to differing data formats from different sources;

(c) to establish a coherent set of analysis options to suit the different data types, timescales, etc.;

This topic was first discussed formally in June 2003 at a joint OXF/UCB meeting in Boulder, CO, and the original version of this document was written shortly thereafter. Since that time various suggestions have been made, some independent work has been done on additional tools and much experience has been gained during CPTs, MTs and SCIF tests. Also, some historical trend data have been accumulated and will be used to form the basis for an ongoing trend archive.

Criteria & Basic Approach

Some important criteria for proper instrument performance monitoring are:

(a) **completeness** - every instrument performance-related item should be regularly monitored;

(b) **timeliness** - maximum information should be extracted as soon as possible;

(c) **clarity** - analysis products must be clearly presented and identified;

(d) **reporting** - analysis results must be made available as quickly as possible;

(e) **alerting** - a mechanism is required to alert personnel if a problem is detected;

(f) **archiving** - data must be stored and indexed for easy future retrieval;

(g) **trending** - important items should be cumulatively plotted over appropriate time periods;

(g) **tracking** - regular telecons and/or meetings are needed to discuss results and possible changes.

To meet the above criteria, bearing in mind the different types of data to be processed, three distinct processes for HIRDLS data analysis have been proposed:

(i) [Tool #54 in Tools List) A fast data scrub using a Quick-look tool (QLT). This would use Science Stream HK data or Engineering Stream data, would be automatic and would detect specific out-of-limit conditions and other anomalies which may indicate a potential instrument problem requiring relatively urgent attention. Analog data channels and some status flags/words would be examined by this tool. The QLT process would run in near-real time on each orbit/granule of data. A local limits database would be used, frequently updated ("tuned") to optimise efficiency, i.e. to maximise sensitivity and minimise false alarms. This is the automatic tool described in TC-UCB-066A which, at the time of writing, is in an advanced state of development at UCB.

It is envisaged that the raw data used by the QLT would be extracted from packets to ‘flat’ files, which would be archived. Subsequent operations would where possible use the data in the flat files.

(ii) [Tool #12 in Tools List] SAIL status and memory dump analysis. This tool compares SAIL telemetry and IPU memory dump data with reference memory images and interprets several SAIL parameter combinations; it is not be amenable to analysis by the QLT. This process will run in near-real time on each orbit/granule of data, and would produce various result files

(iii) [Several tools in Tools List] Detailed analyses intended to extract performance and trend information at both instrument and subsystem level. Responsibility for detailed analyses will ideally be assigned to named individuals. These analyses would be performed using archived data and results would be reported daily / weekly / monthly as appropriate, depending on the specific data and the type of analysis. Analysis products will be stored on the UCB SIPS.

During periods of 'high' activity, e.g. during post-launch activation, re-activation following an anomaly, etc. some of the tools used for routine analysis would be used in near-real time (up to say one hour) for immediate examination of parameters of particular interest or urgency.

Data Streams & Data Sources

The HIRDLS instrument produces two data streams, the “Science stream” and the “Engineering stream”. All HIRDLS telemetry data is contained in the Science stream, while a restricted (and to some extent less precise) subset is copied into the low-rate Engineering stream. Both data streams are continuously recorded on board the S/C, the recorded data normally being transmitted to the ground (i.e. in ‘playback’ mode) during each ground-station contact (“pass”). ‘Live’ Engineering stream data is also transmitted to the ground station during a pass to enable commands and status to be verified in real time at the EOC.

During each pass the Instrument Support Terminal (IST) “Windows” monitors at Boulder and Oxford can display real-time Engineering stream data, and - when applicable - the running of command (STOL) procedures. These data are not stored locally at this time.

Following a pass, the real-time Engineering stream data collected during the pass (approx 15-minutes per orbit) will be transmitted to each IST Sun HDD, but it is not expected that this will be routinely used. It may be useful if the normal data sources are temporarily lost or for retrospective checking in the event of a suspected data anomaly.

Since the Science stream data will be available at both Boulder and Oxford in a timely way, it is proposed that all formal analysis activities described in this document be performed on the Science stream data. Possible data sources, in order of increasing latency (staleness) are:

a) Rate-buffered data [RBD]stream: consists of approximately one orbit (100 minutes) of HIRDLS ‘playback’ data, available within approx. 30 minutes of end of each pass;

b) Level-0 “expedited” data stream [EDS]: consists of approximately 2-hour (120-minute) granules of HIRDLS data, available approx. 3 hours after playback; **note:** - maximum of 2% of orbits !

c) Level-0 “production” data stream [PDS]: consists of approximately 2-hour (120-minute) granules of HIRDLS data, available approx. 15 hours after playback.

RBD will be transmitted after each pass to dedicated servers at Boulder and Oxford. The Level-0 data will be transmitted to the SIPS at Boulder. The data streams in both cases will consist of HIRDLS CCSDS packets. The Level-0 packets are expected to be time-ordered, without duplicates. The RBD may not be time-ordered and may include duplicates.

Data File Formats - Use of LM Tools

It should be noted that the tools developed by LM for reading HIRDLS telemetry data were - for obvious reasons - made compatible with the IEGSE data file format, and will not read raw Level-0 or RBD format files. LM have now provided a conversion tool (#55 in Tools List) to allow quick and easy conversion of RBD and Level-0 data files to IEGSE format, thus allowing existing LM-developed analysis tools to be used directly. This seems a very significant forward step.

Requirements for Viewing Data at EOC

During the first few weeks following launch, activity will be centred at the EOS Operations Center, and means must be provided for viewing and analysing HIRDLS data in a timely way. As mentioned earlier, some of the tools used for routine analysis at UCB and Oxford will be required for immediate assessment of instrument performance parameters at the EOC. This will require the installation of suitable hardware within the Instrument Support Room (ISR) as well as the provision of adequate data links to receive or download HIRDLS data, probably involving penetration of the local 'firewall'. This is seen as a temporary arrangement, covering particularly the Launch & Early Orbit (LEO) period during which Lockheed Martin (LM) will have contractual responsibility for the health & safety of the instrument.

Transition from LEO to Routine Operations

It is envisaged that the data tools and analysis methods used by LM prior to launch will continue to be used during the LEO period in order to provide continuity and direct comparability of pre- and post-launch performance. Overlapping this period, these and other recently-developed data tools will be exercised and optimised for routine long-term operations. Care will be taken to preserve maximum 'seamless' processing: in particular, trend charts/files will be continued on the same basis as for pre-launch.

Quick-look Analysis

Two options have been proposed for automatic QL processing of the HK data:

Option A: run the Quick-look Tool on the RBD server, using the RBD stream;

Option B: run the Quick-look Tool on the SIPS, using the Level-0 PDS.

Option A is preferred and recommended for two reasons: (i) the results will be available many hours earlier, and (ii) there are significant System Management advantages in restricting the SIPS to formal 'production' processing activities. It may be noted however that a QLT which is designed to operate on an RBD file will also be capable of operating on a Level-0 file.

It is proposed that the QLT be designed to operate on the RBD both at Boulder and at Oxford. It will be developed from the UCB "DAAS" software and will perform the following tasks once per orbit:

(a) sort the RBD packets into a time-ordered set without duplicates;

(b) extract the data from the CCSDS packet format to the basic HIRDLS packet format;

(c) decode the 'GIRD' and 'HIRDLS' packet headers to determine the data block boundaries, Time Stamp, etc.;

(d) extract selected HK analog items into one or more flat file formats (e.g. ASCII/.csv);

(e) extract HK status flags & nibbles ("sub-tmi" items) for subsequent masking, "limit" checking, etc.;

(f) scan the flat files with respect to e.g. high/low limits, >3-sigma events, scatter (noise) - as applicable - and note any out-of-limit items or anomalies; limit tables would be compiled and subsequently refined as required for the specific purposes described in this document; they would be quite distinct from the limit tables in the EOC database;

(g) generate an ASCII text Quick-look Report (QLR) listing: item mnemonic, time tag, data value and limit value [TBC] * ;

(h) transmit the QLR in the body of an email to a TBD distribution list *.

* steps g) & h) would be performed on any given day either by UCB or by Oxford - not both !

Note: see TC-UCB-066A for latest description of this automatic QLT

The flat file(s) referred to in steps (d) and (e) will be archived on an appropriate server for general access by the HIRDLS team. Data will be stored both as raw counts and - where applicable - converted to physical units using (initially at least) the same conversion equations & coefficients as those used in the EOC/PDB. Other standard reduced-data products generated by running the QLT (e.g. plots, statistics) **may** also be archived, but it is expected that subsequent detailed analysis would normally use the flat files as the data source (where they exist). It will be possible to request all data for a given time span, or data subsets specified by time-span and mnemonic (up to TBD maximum).

Monitoring of SAIL Task Operation, Memory Dumps, etc.

This process will not be compatible with the QLT as it requires too much adaptive and/or interactive checking against stored tables, memory maps and SAIL task settings. Oxford is already developing tools for this process, and these have been used during previous Mission and SCIF tests at EOC. Invariant SAIL parameters and data will be checked against daily trickle dumps of IPU memory and SAIL task schedules. Command and status telemetry will also be checked against expected SAIL and MCL commanding to verify correct operation of measuring sequences. Scanner and SSH Door operation will also be tracked and verified against running SAIL task parameters.

Plans for Detailed Analysis

It was originally proposed that detailed HK data analysis and long-term trending be allocated by subsystem and assigned to a named individual whose responsibilities would include "Initial Analysis Planning to be completed well before launch, i.e: listing [items] to be included in his/her analysis, specifying the type of analysis to be performed, e.g. running average; peak to peak (max / min) around orbit or other relevant period; rms; scatter/noise; long-term trend; etc. . . [and] for status words & flags: bit masks/comparisons, combinations, statistics, etc. "

The above was written 9 months ago (in this document) but unfortunately progress on this aspect has been nil. Consequently, this 'planning' has been completed in the last few days and the results presented, subject to review, on the accompanying Excel sheets.

Other planning objectives included establishing schedule for regular analysis operations (e.g. some daily, some less frequently) and defining which output products are to be generated, which of these should be temporarily stored (e.g. 1 week) and which should be archived. These objectives have also been addressed and the results included on the Excel sheets.

Routine Detailed Analysis & Reporting

Following launch the following routine activities are required:

(i) Perform analysis runs per schedule

(ii) Generate regular text reports per agreed format and schedule

(iii) Submit report & subset of output products to HIRDLS central engineering data archive to be stored on the UCB SIPS; numerical products should be supplied in ASCII/.csv format; graphical products should be supplied as jpeg, gif, or pdf files.

Proposed Assignments to Institutions/Individuals

The following assignments were provisionally agreed at the June 2003 HIRDLS meeting in Boulder:

STH	OXF/Whitney	**DSS**	UCB/Lee/Dials
SSH	OXF/Barnett	**IFC**	OXF/Hepplewhite
SVA	OXF/Barnett	**IPS**	OXF/Barnett/Whitney
GSS	OXF/Oduleye	**CSS**	UCB/Woodard
TSS	UCB/Woodard (may need to be split)	**PSS**	OXF/Whitney

Note 1: the above assignment are intended to apply after LEO operations, when Flight Ops are handled entirely by the IOT (OXF/UCB), with LM acting in an 'as-required' support role. During LEO, assignment of tasks is an LM responsibility.

Note 2: TC-UCB-066A states that "All of the subsystems have been assigned to one of the three [UCB] analysts. The analysts have the responsibility of deciding what analysis/trending is appropriate for the subsystem and prioritizing the order in which it will be accomplished". As stated above, as we are now close to launch, 'appropriate analysis/trending' details have already been defined as shown in TC-OXF-423. Also, it appears that UCB intends to analyse telemetry from all instrument subsystems, not only those allocated to UCB in June 2003. No recent discussion or coordination has yet occurred on this aspect.

Daily Operations Summaries and Performance Reports

An important IOT function will be to generate daily operations summaries showing HIRDLS modes, special calibrations, etc. A daily MCL log must also be kept, which may be the MCL file as submitted to EMOS or may be a summary [TBD]. Regular HIRDLS Performance Summary Reports will need to be generated from the individual subsystem analysts' reports. Where practical these products should be in plain ASCII text suitable for email, and will be archived in the HIRDLS CEDA.

Guidelines & Standardisation

The original release of this document stated that "it would seem to be a good idea - once the general details have been agreed - for all analysts to use the same basic formats and procedures, within practical limits, for handling the various subsystem data sets and generating archive products, reports, etc."

It has since been generally agreed, or become self-evident, that a single tool set should be used for all data items (see Tools List). This will hopefully accomplish the above aim.

Future Planning Activities

'TBDs' to be resolved are:

- precise content & format for Quick-look Report (QLR)
- distribution for QLR emails
- maximum number of mnemonics for limited source data requests
- format for MCL file/summary

/ Acronyms & Abbreviations . . .

Acronyms & Abbreviations

CPT	Comprehensive Performance Test
EDS	Expedited Data Set
EOC	EOS Operations Center
HDD	Hard Disk Drive
HK	Housekeeping
IST	Instrument Support Terminal
MT	Mission Test
MCL	Mission Command Load
PDB	Project Data Base
PDS	Production Data Set
QL	Quick Look
QLR	Quick Look Report
QLT	Quick Look Tool
RBD	Rate Buffered Data
SAIL	Science Algorithm Implementation Language
SCIF	Spacecraft Interface
SIPS	Science Investigator-led Processing System
STOL	Satellite Test & Operations Language